THE OBLIQUELY SUBDUCTING NAZCA RIDGE AT THE PERUVIAN ACTIVE MARGIN: THE PRESENT COLLISION ZONE AND A RE –EVALUATION OF ITS MIGRATION HISTORY

Andrea HAMPEL (1), Nina KUKOWSKI (1), Joerg BIALAS (2), Udo BARCKHAUSEN (3)

(1) GeoForschungsZentrum Potsdam, Telegrafenberg, D-14473 Potsdam, Germany (andrea@gfz-potsdam.de)
(2) GEOMAR Research Center of Marine Geosciences, Wischhofstr. 1-3, D-12148 Kiel, Germany
(3) BGR, Stilleweg 2, D-30361 Hannover, Germany

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ABSTRACT

At the Peruvian convergent margin, the oceanic Nazca Plate subducts obliquely beneath the South American continent at a convergence rate of ~61 mm/a. The age of the subducting plate varies from 28 Ma to 38 Ma at the trench south and north of the Mendana Fracture Zone, respectively (Fig.). A prominent feature off Peru, which plays an important role in the evolution of the margin, is the 1.5 km high and 1000 km long submarine Nazca Ridge. This ridge migrates southward along the margin due to its oblique orientation to both the convergence direction and the trench line. The present collision zone of the Nazca Ridge and the Peruvian margin between 14°S and 17°S is characterized by deformation of the upper plate and several hundred meters of uplift in the forearc which is expressed by a narrowing of the shelf, an eastward shift of the coastline and the presence of marine terraces. South Peru also suffered from strong earthquakes of magnitude M_w = 8.1 and M_w = 7.7 in 1942 and 1996, respectively, which occurred near the continuation of the crest of the ridge and south of it. On 23 June 2001, an earthquake with a magnitude of M_w = 8.4 and several aftershocks of magnitude M_w = 6.0 and larger ruptured the coastal area at the southern edge of the intersection zone of the Nazca Ridge and the margin.

The Nazca Ridge and its collision zone with the trench was imaged by bathymetric and wide-angle seismic data during the RV "Sonne" cruise SO146–GEOPECO in spring 2000 off Peru between 5°S and 15°S. The data reveal that the southeastern flank of the ridge, which marks its leading edge entering the trench, has a rather smooth topography compared to the rough relief of the surrounding Nazca Plate. The sediment cover on the ridge does not exceed a thickness of 300 m. Several volcanic structures of different size and elevation can be identified on its surface. As they seem quite intact, they may have formed after the origin of the main part of the ridge. Towards the trench, an increasing number of trenchparallel normal faults, which are caused by the bending of the ridge into the subduction zone, can be identified. The trench is characterized by a rough surface and little to no sediment fill. Where the crest of the ridge enters the trench, the water depth decreases to 5000 to 5300 m compared to a water depth of 6500 m and more south of the intersection area. This is consistent with the amount

of uplift recorded in marine terraces along the coast (Hsu, 1992; Macharé and Ortlieb, 1992). The lower continental slope is very steep and shows features typical of erosion. There is no evidence for the presence of a former or present accretionary prism. The wide-angle seismic profiles indicate a thickened crust of up to 17 km for the ridge with seismic velocities typical of oceanic crust. The depth of the Moho varies laterally, thus the ridge seems to have a slightly assymmetrical root. The incoming sediments are assumed to be completely subducted since an accretionary wedge cannot be identified in the seismic data. The angle of the lower slope is larger than north of the Nazca Ridge, therefore, the continental slope may undergo enhanced short-term erosion due to the ridge subduction which is superposed on a long-term erosional regime of the Peruvian margin. The Nazca Plate, which can be traced to a depth of about 28 km, subducts at an angle of about 9°.

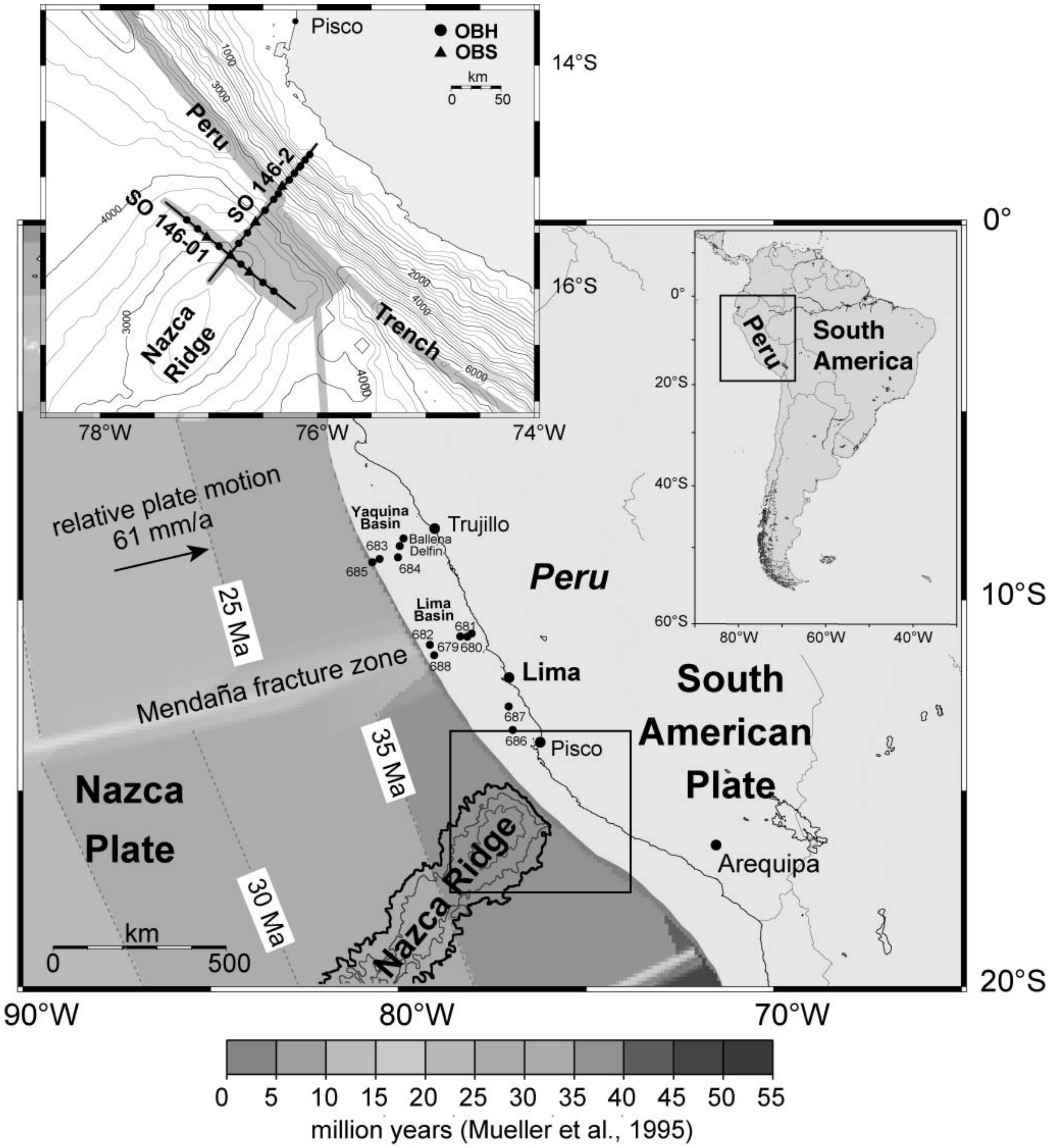

Fig.: Location map of the Peruvian margin. The working area of the SO146-GEOPECO cruise at the Nazca Ridge is marked by box (grey: area covered by multibeam bathymetry; black lines: wide-angle seismic profiles) Black circles mark drilling sites (ODP Leg 112 and two industrial wells).

For reconstructing the migration history of the Nazca Ridge, updated plate motion data (Somoza, 1998), resulting from a revision of the geomagnetic time scale (Cande and Kent, 1995), are used to construct paleo-positions of the Nazca Ridge. Due to the deceleration of the Nazca Plate motion and the variable orientation of the ridge with respect to the trench, the ridge crest moved at a significantly decreasing velocity parallel to the margin. During the 4.9-0 Ma time interval, the average lateral migration velocity of the ridge has been 4.3 cm/a. Constraining the length of the original Nazca Ridge by its conjugate feature on the Pacific Plate yields that the subduction of the ridge began ~11 Ma ago at 11°S. Therefore, the Nazca Ridge did not affect the northern sites of Ocean Drilling Program (ODP) Leg 112 located at 9°S. For the Lima Basin region at 11.5°S, the model suggests the passage of the ridge crest 9 Ma ago. The results of the model are supported by the marine and subaerial sedimentological record of the Peruvian forearc.

The results of the reconstruction of the migration history offer the possibility to compare regions that have not been affected by the ridge passage (9°S) with regions that have been (12°S) and are presently (15°S) influenced by the ridge, but otherwise have similar geodynamic boundary conditions. The data collected at different latitudes during the SO146-GEOPECO cruise enables to compare these regions of different tectonic development to better quantify the geodynamic influence of the Nazca Ridge on the Peruvian margin.

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